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UTILIZATION OF SHUTTLE SMALL PAYLOAD ACCOMMODATIONS IN THE DOD SPACE TEST PROGRAM

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ABSTRACT

Over the past 27 years, the US Air Force, as executive agent for the Department of Defense (DOD) Space Test Program, has flown approximately 325 space experiments for the Army, Navy, Air Force, and other DOD agencies not authorized their own means of spaceflight. These experiments have made significant contributions to the improvement of military technology and operations.

Flight of Space Test Program experiments has been carried out utilizing free flyer spacecraft, the Space Shuttle crew cabin, and the Space Shuttle cargo bay. This paper will concentrate on those experiments which have been flown by the NASA Space Shuttle small payload flight systems, e.g., GAS, uprated GAS (CAP), and Hitchhiker flight systems.

Discussion of Space Test Program experiments flown by Space Shuttle small payloads flight systems will include the experiment objectives, the accommodations and services provided by the flight systems, experiment results, and lessons learned from the planning and conduct of the flight. Particular emphasis will be placed on those experiments which required and were provided with a new and unique capability by the small payloads flight systems. These capabilities include the first use of the GAS opening lid, the first use of the GAS payload ejection capability, and the first use of the Hitchhiker cross bay carrier.

INTRODUCTION

Figure 1 lists the three major categories of experiments that have been conducted by the DOD Space Test Program (STP).

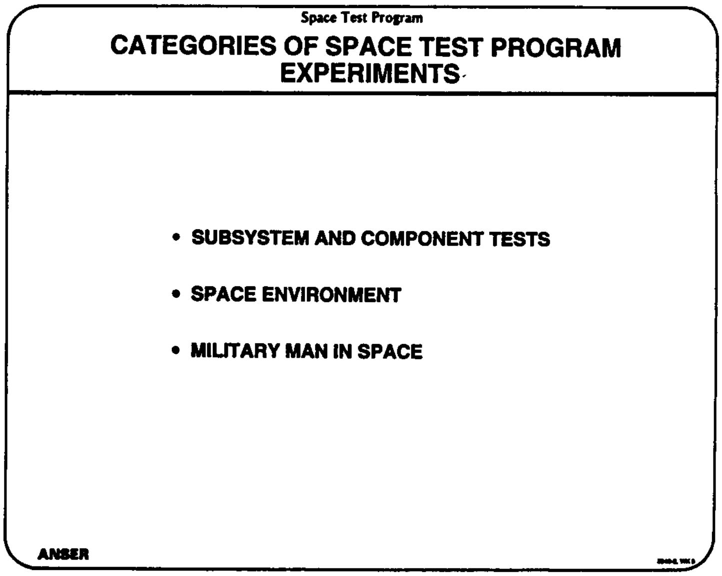

Figure 1

The objective of experiments related to subsystem and component tests is to proof test and demonstrate components which are more reliable, more survivable, or have improved performance. STP has flown 67 experiments related to component and subsystem tests. The purpose of experiments related to the space environment is to understand the environment where

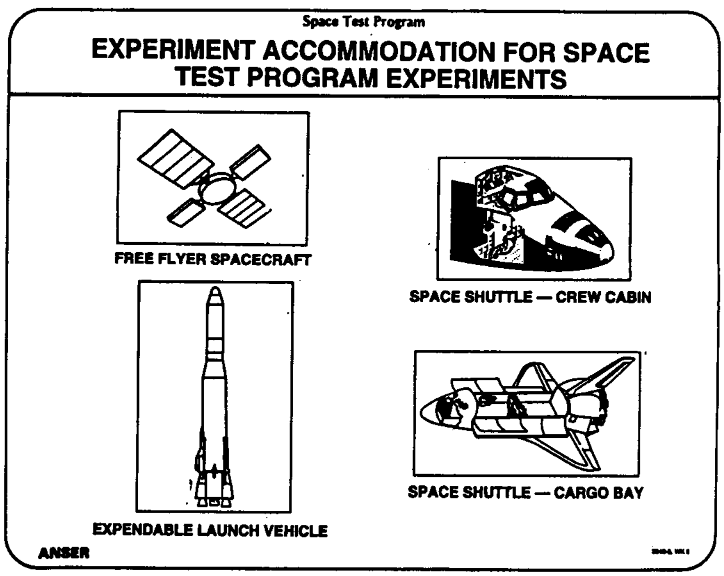

Figure 2

military systems, such as communication systems, must operate. STP has flown 171 experiments related to the environment. Finally, STP has conducted 28 experiments related to military man in space. The objective of these experiments is to determine if there are useful military activities which can be best carried out by a man in space.

Figure 2 illustrates the various types of flight systems which have been utilized by STP to fly experiments. Spacecraft launched by expendable launch vehicles have provided accommodations for STP experiments throughout the life of the program. Frequently the Space Test Program has been able to "piggyback" STP experiments on spacecraft of other flight programs. Approximately 50 experiments have been flown by STP in the Shuttle crew cabin, including all of the experiments related to military man in space. Except for two missions which involved very large payloads, all of the STP experiments which have flown in the shuttle cargo bay have been flown by the Goddard Shuttle small payloads program.

Space Test Program

SUMMARY OF SPACE TEST PROGRAM EXPERIMENTS FLOWN BY SHUTTLE SMALL PAYLOADS PROGRAM

DATE	MISSION	STP EXPERIMENT DESIGNATION	CARRIER
1983	STS 31C	NRL-904A	GAS
1984	STS 41B	SD-301	GAS
	STS 41G	NRL-905	GAS
1985	STS 51B	DARPA-401	GAS
	STS 51G	NRL-904B	GAS
	STS 61A	DARPA-401	GAS
1986	STS 61C	AFA-301	GAS
		AFGL-402	HITCHHIKER G
1988	STS 27	SD-301	GAS
1989	STS 28	AFTAC-402	GAS
	STS 33	SD-301	GAS
1991	STS 39	NRL-904	HITCHHIKER M
		SD-602	
		AFGL-501	
1992	STS 42	NPS-603	GAS
	?	AFGL-502	GAS
	STS 53	WRDC-001	HITCHHIKER G
		GL-601	HITCHHIKER G

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Figure 3

Figure 3 summarizes the DOD STP experiments that have been flown by the Shuttle small payloads program. STP has utilized this program consistently over the past ten years. These Shuttle small payload experiments have been of a wide variety of types, as will be demonstrated shortly as each of these missions and experiments is presented.

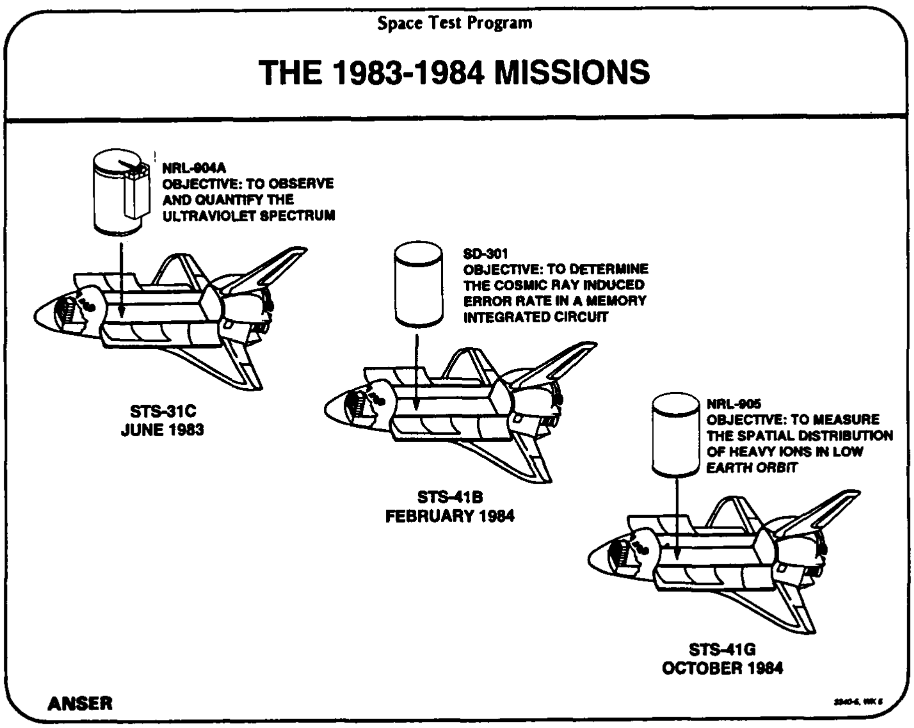

Figure 4

Figure 4 illustrates the accommodations and objectives of the STP experiments flown by the small payload program in the 1983-1984 time frame. All three of these experiments acquired useful experimental data. Of particular interest is the Get-Away Special (GAS) can with the opening lid that was flown in 1983. STP recognized early that the capability of the GAS can for flying experiments could be improved substantially by providing a lid that could be opened in orbit. STP provided advice and assistance, including financial assistance, to the Goddard small payloads program for the design and fabrication of the opening lid. the opening lid has been used for a number of subsequent GAS can experiments. This first group of experiments also gave STP experimenters their first experience with the extensive safety requirements for flight of an experiment on a manned spacecraft.

THE 1985-1986 MISSIONS

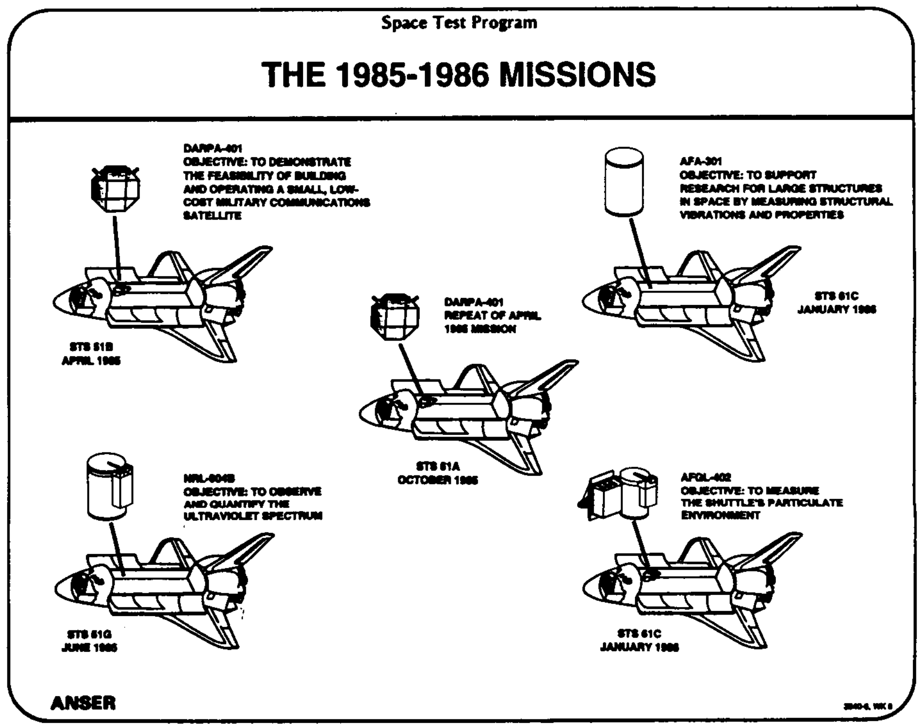

Figure 5

Figure 5 illustrates the accommodation and objectives of the STP experiments flown by the Goddard Shuttle small payloads program in the 1985-1986 frame. This period marked the first use by STP of two new types of Shuttle small payload accommodation. For some time, DOD has been interested in the idea of a battlefield communications system based on space assets. Such a "store and forward" message system would have to be reliable, inexpensive, easy to launch, and have a lifetime of at least several months. Such a system was tested by the DARPA-401 missions in 1985. The first flight failed because malfunction of the GAS can lid did not allow the satellite to deploy. The second flight deployed the satellite properly. It operated satisfactorily for one year. NRL-904B was a repeat of the NRL-904A experiment flown in 1983. No useful data was obtained due to an electronic malfunction. AFA-101 demonstrated that a GAS can can be used to support research for large structures in space by measuring structural vibrations. Finally, AFGL-402 measured the Shuttle's particulate environment in STP's first use of the Hitchhiker G experiment accommodation. This experiment was 100 percent successful.

THE 1988-1989 MISSIONS

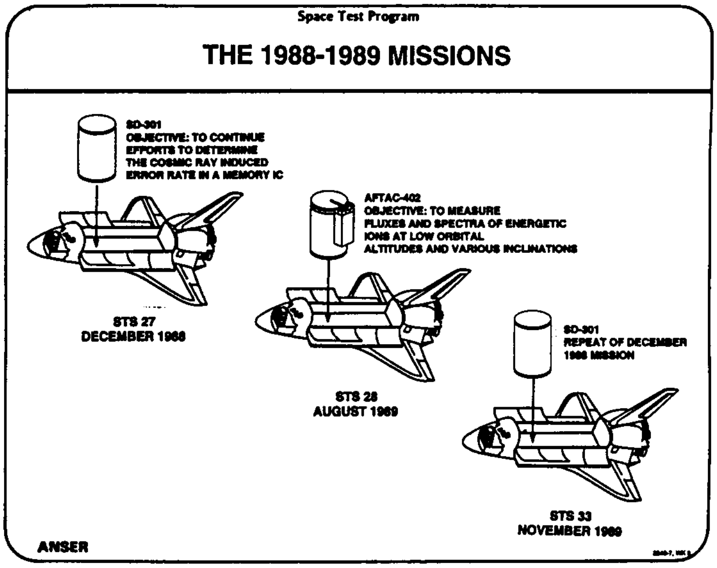

Figure 6

In the 1988-1989 time frame, as the Shuttle began to fly again after the Challenger accident, STP flew three GAS can experiments, as shown in Figure 6. Useful experimental data was obtained from both flights of experiment SD-301. This data was used to validate the analytical model of cosmic ray-induced error rate in a memory integrated circuit. The AFTAC-403 experiment was partially successful. Data from this experiment was used to evaluate detector performance for free flyer spacecraft missions.

THE 1991-1992 MISSIONS

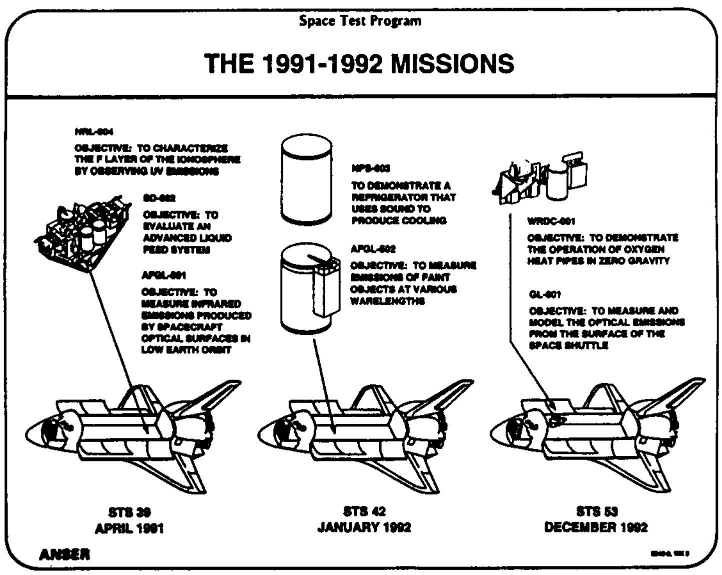

Figure 7

In the 1991-1992 time frame, as illustrated in Figure 7, STP utilized the expanded payload capability of the Goddard Shuttle small payloads Hitchhiker M carrier to fly three substantial experiments. The three experiments together weighed approximately 1,000 pounds. The successful accomplishment of these experiments was aided by the Hitchhiker system's real-time communications with the experiments. Shuttle mission STS-42 flew two successful STP GAS can experiments. One of these experiments demonstrated a space refrigerator which used sound to produce cooling. The other experiment measured the emissions of faint objects in space. Shuttle mission STS-53 carried two successful STP experiments on Hitchhiker G accommodations. One of these experiments demonstrated the operation of an oxygen heat pipe in zero gravity; the other experiment measured the optical emissions from the surface of the Space Shuttle.

POTENTIAL FUTURE MISSIONS

Each year the DOD Space Test Program holds a Tri-Service meeting to discuss and prioritize space experiments which have been proposed for flight. Based on the May 1993 meeting, STP has approximately 50 experiments on the current priority list. After eliminating experiments that require long duration flight or an orbit not achievable by the Space Shuttle, and also eliminating those experiments that require flight in the Shuttle crew cabin, the experiments listed on Figure 8 were selected as good candidates for flight by the Shuttle small payloads program. Detailed analyses of these experiments will be made by the STP office responsible for experiment flight planning.

Space Test Program

A PRELIMINARY LOOK AT POSSIBLE FUTURE STP/SHUTTLE SMALL PAYLOAD CANDIDATES

EXPERIMENT OBJECTIVE	CANDIDATE CARRIER
• DEMONSTRATE ULTRAVIOLET SENSORS	HITCHHIKER
• OBSERVE BEHAVIOR OF LIQUID METAL HEAT PIPES IN SPACE	HITCHHIKER
• DEMONSTRATE A PHASE CHANGE MATERIAL LIGHTWEIGHT HEAT STORAGE DEVICE	HITCHHIKER
• LOW-COST PACKET COMMUNICATIONS SATELLITE	CAPP
• MEASURE INFRARED EMISSIONS FROM SHUTTLE SURFACES	HITCHHIKER

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Figure 8

SUMMARY AND OBSERVATIONS

Space Test Program

SUMMARY AND OBSERVATIONS

- THE SHUTTLE SMALL PAYLOADS PROGRAM IS A VERY COST-EFFECTIVE MEANS OF FLYING SPACE EXPERIMENTS
- STP HAS BEEN ABLE TO FLY A WIDE VARIETY OF EXPERIMENTS IN THE SHUTTLE SMALL PAYLOADS PROGRAM
- GODDARD SHUTTLE SMALL PAYLOADS PROGRAM SUPPORT TO STP EXPERIMENTERS HAS BEEN EXCELLENT THROUGHOUT STP PARTICIPATION IN THE PROGRAM
- MEETING SHUTTLE SAFETY REQUIREMENTS IS THE MOST DIFFICULT TASK IN PARTICIPATING IN THE SHUTTLE SMALL PAYLOADS PROGRAM

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Figure 9

Figure 9 lists some observations relating to STP participation in the Shuttle small payloads program. The program is without doubt the most cost-effective flight program in existence for the flight of space experiments.

As some of the earlier examples indicated, STP has been able to fly experiments in the Shuttle small payloads program, ranging from subsystem tests to environmental measurements. STP has also been able to fly experiments that weigh up to several hundred pounds and experiments that require real-time communications during flight.

STP experimenters have uniformly offered high praise of the members of the Shuttle small payloads office, who frequently have gone the extra mile to make the integration and flight of the experiment a success.

Experimenters considering using the Shuttle small payloads flight accommodations must recognize that their experiment will be flying on a manned flight system, and safety requirements are substantial. Work to support safety analysis must start early and must be completed satisfactorily.